

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method of measuring at least one selected parameter at a location within a region of interest, which method comprises the steps of:

launching optical pulses at a plurality of preselected interrogation wavelengths into an optical ~~fi~~~~bre~~ fiber deployed along the region of interest, reflectors being arrayed along the optical ~~fi~~~~bre~~ fiber to form an array of sensor elements, the optical path length between the said reflectors being dependent upon the selected parameter;

detecting the returned optical interference signal for each of the preselected wavelengths;
and

determining from the optical interference signal the absolute optical path length between two reflectors at the said location, and from the optical path length so determined the value of the selected parameter at the said location.

2. (Original) A method as claimed in claim 1, wherein the step of determining the absolute optical path length comprises carrying out a process in which the derivative of the phase as a function of wavelength is estimated from a subset of the interference signals, using the derivative and an estimated value for the optical path length to estimate the phase relationship between the interference signals, and the phase relationship thus obtained is used to revise the estimated value for the optical path length, the process being repeated for increasing subsets of the remaining wavelengths in sequence, on the basis of the optical path length estimated for the immediately preceding subset in the sequence, thereby to progressively revise the optical path length until it is known to a desired level of accuracy.

3. (Canceled)

4. (Currently Amended) A method as claimed in claim 1, wherein said optical ~~fi~~~~bre~~ fiber comprises ~~polarisation~~ polarization-maintaining ~~fi~~~~bre~~ fiber and light is launched into the ~~fi~~~~bre~~

fiber in such a way that the power of the light signal is substantially equally divided between the orthogonally-~~polarised~~ polarized propagation modes of the ~~fi~~bre fiber, thereby to interrogate each principal state of ~~polarisation~~ polarization of the ~~fi~~bre fiber simultaneously, the return interference signals from both principal states of ~~polarisation~~ polarization being used separately in the said process for determining the absolute optical path length for each propagation mode independent of the other mode.

5. (Currently Amended) A method as claimed in claim 1, wherein the optical ~~fi~~bre fiber comprises ~~polarisation~~ polarization-maintaining ~~fi~~bre fiber and light is launched into the ~~fi~~bre fiber in such a way that the power of the light signal is firstly directed entirely into one of the principal states of ~~polarisation~~ polarization and then the other, thereby to interrogate the principal states of ~~polarisation~~ polarization sequentially, the returned interference signals from both principal states of ~~polarisation~~ polarization being used separately in the said process for determining the absolute optical path length for each propagation mode independent of the other mode.

6. (Previously Presented) A method as claimed in claim 1, in which the selected parameter comprises temperature.

7. (Canceled)

8. (Canceled)

9. (Canceled)

10. (Previously Presented) A method as claimed in claim 1, in which the selected parameter comprises strain.

11. (Currently Amended) A method as claimed in claim 10, wherein the optical ~~fi~~bre fiber is a high-birefringence ~~fi~~bre fiber, the birefringence of which changes in response to strain applied to the optical ~~fi~~bre fiber.

12. (Currently Amended) A method as claimed in claim 11, wherein the birefringence of the high-birefringence ~~fi~~bre fiber also changes in response to temperature, and the method further comprises compensating the returned optical interference signal for effects arising from temperature at the said location.

13. (Canceled)

14. (Previously Presented) A method as claimed in claim 1, in which the selected parameter comprises pressure.

15. (Currently Amended) A method as claimed in claim 14, wherein the said optical ~~fi~~bre fiber comprises a side-hole ~~fi~~bre fiber.

16. (Currently Amended) A method as claimed in claim 15, wherein each sensor element of the ~~fi~~bre fiber is located within a sealed elliptical tube filled with a pressure-transmitting fluid.

17. (Canceled)

18. (Canceled)

19. (Currently Amended) A method as claimed in claim 1, wherein the selected parameter depends on a localized ~~localised~~ event moving along the region of interest, and the method comprises determining the value of the selected parameter over time at more than one said location, and determining the movement of the localized ~~localised~~ event from the determined values of the selected parameter.

20. (Currently Amended) A method as claimed in claim 19, wherein the localized ~~localised~~ event is a user-induced event, and the method further comprises inducing the localized ~~localised~~ event.

21. (Currently Amended) A method as claimed in claim 19, wherein the localized ~~localised~~ event is a volume of fluid within the region of interest that has a different temperature, pressure, or density from surrounding fluid in the region of interest, the selected parameter being temperature, pressure, or density, respectively.

22. (Previously Presented) A method as claimed in claim 1, wherein at least two selected parameters are measured simultaneously.

23. (Canceled)

24. (Canceled)

25. (Canceled)

26. (Currently Amended) A method as claimed in claim 1, wherein the measured value for the parameter is used to determine the value for a further measurand dependent upon the said parameter and wherein the said optical ~~fiber~~ fiber is provided with a coating which responds to the said further measurand by stretching or shrinking.

27. (Canceled)

28. (Previously Presented) A method as claimed in claim 26, wherein the said coating is electro-strictive.

29. (Previously Presented) A method as claimed in claim 26, wherein the said coating is magneto-strictive.
30. (Previously Presented) A method as claimed in claim 26, wherein the said coating is sensitive to a selected chemical measurand.
31. (Canceled)
32. (Canceled)
33. (Canceled)
34. (Canceled)
35. (Previously Presented) A method as claimed in claim 1, wherein the returned optical interference signal is processed to remove the cross-talk term, the cross-talk term being removed for each of n sensor elements by subtracting the cross-talk phasor for the nth sensor element from the measured nth sensor element phasor, the removal process beginning with subtraction of the cross-talk phasor for the second sensor element from the measured second sensor element phasor, the cross-talk phasor for the first sensor element in the array being zero.
36. (Previously Presented) A method according to claim 1, wherein the region of interest lies within an oil well.
37. (Canceled)
38. (Canceled)

39. (Currently Amended) Apparatus for measuring a selected physical parameter at a location within a region of interest, which apparatus comprises:

an optical ~~fi~~bre fiber for deployment along the region of interest, the optical ~~fi~~bre fiber having reflectors therealong forming an array of sensor elements, the optical path length between the said reflectors being dependent upon the selected parameter;

source means operable to launch optical pulses at a plurality of preselected interrogation wavelengths into the said ~~fi~~bre fiber;

signal detection means operable to detect the returned optical interference signal for each of the preselected wavelengths; and

signal processing means operable to determine from the optical interference signal the absolute optical path length between two reflectors at the said location and to determine from the optical path length so determined the value of the selected parameter at the said location.

40. (Original) Apparatus as claimed in claim 39, wherein the said signal processing means is operable to determine the absolute optical path length by carrying out a process in which the derivative of the phase as a function of wavelength is estimated from a subset of the interference signals, using the derivative and an estimated value for the optical path length to estimate the phase relationship between the interference signals, and the phase relationship thus obtained is used to revise the estimated value for the optical path length, the process being repeated for increasing subsets of the remaining wavelengths in sequence, on the basis of the optical path length estimated for the immediately preceding subset in the sequence, thereby to progressively revise the optical path length until it is known to a desired level of accuracy.

41. (Canceled)

42. (Currently Amended) Apparatus as claimed in claim 39, wherein the said optical ~~fi~~bre fiber comprises ~~polarisation~~ polarization-maintaining ~~fi~~bre fiber, and the apparatus further comprises power launching means operable to launch the optical pulses into the ~~fi~~bre fiber in such a way that the power of the optical pulses is substantially divided between the orthogonally-

~~polarised~~ polarized propagation modes of the ~~fibre~~ fiber, thereby to interrogate each principal state of ~~polarisation~~ polarization of the ~~fibre~~ fiber simultaneously; and the signal processing means being operable to use the returned optical interference signals from both principal states of ~~polarisation~~ polarization separately to determine the absolute optical path length for each propagation mode independent of the other mode.

43. (Currently Amended) Apparatus as claimed in claim 39, wherein the said optical ~~fibre~~ fiber comprises ~~polarisation~~ polarization-maintaining ~~fibre~~ fiber, and the apparatus further comprises a ~~polarisation~~ polarization modulator operable to launch the optical pulses into the ~~fibre~~ fiber in such a way that the power of the optical pulses is firstly directed entirely into one of the principal states of ~~polarisation~~ polarization of the ~~fibre~~ fiber and then the other, thereby to interrogate the principal states of ~~polarisation~~ polarization sequentially; and the signal processing means being operable to use the returned optical interference signals from both principal states of ~~polarisation~~ polarization separately to determine the absolute optical path length for each propagation mode independent of the other mode.

44. (Previously Presented) Apparatus as claimed in claim 39, wherein the parameter comprises temperature.

45. (Canceled)

46. (Canceled)

47. (Canceled)

48. (Previously Presented) Apparatus as claimed in claim 39, wherein the parameter comprises strain.

49. (Currently Amended) Apparatus as claimed in claim 48, wherein the optical ~~fi~~bre fiber is a high-birefringence ~~fi~~bre fiber, the birefringence of which changes in response to strain applied to the optical ~~fi~~bre fiber.

50. (Currently Amended) Apparatus as claimed in claim 49, wherein the birefringence of the high birefringence ~~fi~~bre fiber also changes in response to temperature, and the signal processing means is further operable to compensate the returned optical interference signal for effects arising from temperature at the said location.

51. (Canceled)

52. (Previously Presented) Apparatus as claimed in claim 39, wherein the parameter comprises pressure.

53. (Currently Amended) Apparatus as claimed in claim 52, wherein the said optical ~~fi~~bre fiber comprises a side-hole ~~fi~~bre fiber.

54. (Currently Amended) Apparatus as claimed in claim 53, wherein each sensor element of the ~~fi~~bre fiber is located within a sealed elliptical tube filled with a pressure-transmitting fluid.

55. (Canceled)

56. (Canceled)

57. (Currently Amended) Apparatus according to claim 39, wherein the selected parameter depends on a localized ~~localised~~ event moving along the region of interest, and the signal processing means is operable to determine the value of the selected parameter over time at more than one said location, and to determine the movement of the localized ~~localised~~ event from the determined values of the selected parameter.

58. (Currently Amended) Apparatus according to claim 57, wherein the localized ~~localised~~ event is a user-induced event.

59. (Currently Amended) Apparatus according to claim 58, wherein the localized ~~localised~~ event is a volume of fluid within the region of interest that has a different temperature, pressure, or density from surrounding fluid in the region of interest, the selected parameter being temperature, pressure, or density, respectively.

60. (Previously Presented) Apparatus as claimed in claim 39, and further for measuring a second selected physical parameter at the location within the region of interest, wherein said optical path length between the said reflectors is further dependent upon the second selected parameter; and the signal processing means is further operable to determine the value of the second selected physical parameter from the determined absolute optical path length.

61. (Canceled)

62. (Canceled)

63. (Canceled)

64. (Currently Amended) Apparatus as claimed in claim 61, operable to use the measured value for the parameter to determine a value for a further measurand dependent upon said parameter, and wherein the said optical ~~fibre~~ fiber is provided with a coating which responds to the said further measurand by stretching or shrinking.

65. (Canceled)

66. (Previously Presented) Apparatus as claimed in claim 64, wherein the said coating is electro-strictive.

67. (Previously Presented) Apparatus as claimed in claim 64, wherein the said coating is magneto-strictive.

68. (Previously Presented) Apparatus as claimed in claim 64, wherein the coating is designed to be sensitive to a selected chemical measurand.

69. (Currently Amended) Apparatus as claimed in claim 39, wherein the source means are operable to launch light at a fixed wavelength and at a varying wavelength into the ~~fi~~bre fiber, and the signal processing means are operable to use the interference signal from interrogation at the fixed wavelength to determine high frequency phase changes.

70. (Currently Amended) Apparatus as claimed in claim 69, further comprising an auxiliary optical ~~fi~~bre fiber for deployment through the region of interest, reflectors being arrayed along the ~~fi~~bre fiber to form an auxiliary array of sensor elements, the source means being operable to launch the fixed wavelength signal into the auxiliary ~~fi~~bre fiber.

71. (Currently Amended) Apparatus as claimed in claim 70, where the auxiliary ~~fi~~bre fiber has a coating designed to enhance acoustic sensitivity.

72. (Previously Presented) Apparatus as claimed in claim 69, wherein the signal processing means are further operable to use the high frequency phase changes to correct for dynamic errors in the returned optical interference signals.

73. (Previously Presented) Apparatus as claimed in claim 39, wherein the signal processing means is further operable to process the returned optical interference signal to remove the cross-talk term, the cross-talk term being removed for each of the n sensor elements by subtracting the

cross-talk phasor for the nth sensor element from the measured nth sensor element phasor, the removal process beginning with subtraction of the cross-talk phasor for the second sensor element from the measured second sensor element phasor, the cross-talk phasor for the first sensor element in the array being zero.

74. (Previously Presented) Apparatus according to claim 39, wherein the region of interest lies within an oil well.

75. (Canceled)

76. (Canceled)

77. (Currently Amended) A method of measuring a parameter in an optical ~~fiber~~ fiber interferometric array, comprising:
 launching optical pulses into the array,
 creating an interference signal within sensor elements in the array,
 detecting the phase of the interference signals, wherein the returned optical interference signal is processed to remove the cross-talk term, the cross-talk term being removed for each of n sensor elements by subtracting the cross-talk phasor for the nth sensor element from the measured nth sensor element phasor, the removal process beginning with subtraction of the cross-talk phasor for the second sensor element from the measured second sensor element phasor, the cross-talk phasor for the first sensor element in the array being zero.